Part III: Water Resource Assessments

Chapter 1: Surface Water Monitoring Program

Monitoring and assessment are the cornerstones upon which the state's water quality program rests. Monitoring information is an essential element in environmental management programs. Without data and information, we cannot characterize the condition of the environment, assess and solve problems or evaluate the effectiveness of management and regulatory actions. The overall goal of surface water monitoring is to gather information needed to effectively manage and regulate surface water resources. Furthermore, the Clean Water Act and State of Wisconsin law and associated rules mandate monitoring of surface waters. The collection of information is also essential to educating and increasing public awareness of the environment and environmental issues.

Multiple types of monitoring are implemented to achieve a comprehensive understanding of the state of our surface waters. These types include ambient or baseline monitoring; special project monitoring, long-term trend monitoring, and total maximum daily load monitoring. During the 2004 calendar year, the DNR assembled a draft monitoring strategy which describes the need for various chemical, physical, habitat, and biological monitoring data. Also during the 2004 calendar year renewed special emphasis has been placed on WDNR's use of the USEPA STORET system. An information technology analysis is being conducted to evaluate STORET capabilities in light of federal reporting requirements, water program business needs, WDNR user input and available funding.

Baseline Monitoring

As both the theory and the practice of "comprehensive monitoring" evolve with improved science and understanding, Wisconsin's approach to documenting the baseline quality of its waters continues to change. Historically much of the DNR's monitoring work focused on degraded watersheds or evaluation of waters with a high public profile. Today, our baseline water quality monitoring approach is founded on the premise that our abundance of surface water resources precludes monitoring each resource individually. However, with proper program design not every waterbody need be tested to provide solid spatial coverage of baseline conditions; much can be inferred from good data and information. For example, over 60% of the state's wadeable streams are small, "headwater" first order streams. These streams provide excellent candidates for implementing a random stratified sample design. This statistically valid scientific approach will provide greater breadth to the number of waterbodies assessed under our basic or core water data gathering efforts.

In 2002 Wisconsin piloted the use of a "random stratified sampling technique" for assessing wadable streams for an across-the-board look at the condition of our waters. From this work, WDNR has developed standardized assessment techniques for aquatic habitat, macroinvertebrates and fish that are being applied throughout the state. All data from this baseline monitoring is captured in a web-accessible database.

Baseline monitoring strategies have been developed for four key resource areas: wadeable streams, non-wadeable rivers, lakes, wetlands. Development of baseline protocols is occurring for toxicological monitoring of sediments and fish, as well. Baseline monitoring is intended to provide spatial and temporal aquatic sampling activities to address the following management questions:

- What are the use expectations for Wisconsin's water resources?
- Are the state's waters meeting their use potential?
- What factors are preventing the state's water resources from meeting their potential?
- What are statewide status and trends in the quality of Wisconsin's surface waters?

To achieve program goals, the following specific set of monitoring objectives were established:

- Determine the designated attainable uses of each waterbody. Stream and lake habitat information (including volume, temperature and limited water chemistry) and fisheries data, and stream macroinvertebrate data collected during baseline assessments will be compared with biological criteria obtained from "least-impacted" regional reference waters to determine the water's use classification.
- Determine the level of use attainment of each waterbody. Stream habitat, macroinvertebrate and fisheries data collected during baseline assessment monitoring will allow the WDNR to determine if waterbodies designated uses are being attained.
- Determine why some waterbodies are not attaining their designated uses. Physical, chemical and biological data collected during baseline assessment monitoring will provide some, if not all of the information needed, to determine why streams are not meeting their designated uses.

Monitoring data is captured in the state's Biological and Habitat Database. In the future, this data will be linked to the state's 1:24K hydrography layer for spatial display. The data will also be linked to the Surface Water Integration System (SWIS) for complex analyses.

In addition, the state is responsible for submitting monitoring data to USEPA through STORET. In 2005, WDNR will address various monitoring data needs, including: developing a system to consistently assign, obtain and utilize monitoring site identification codes; ensuring all relevant data is uploaded into the STORET system and exported to USEPA on a regular schedule; and evaluating and developing solutions to enhance accessibility and integration of chemical, physical, habitat and biological data statewide. Resource managers continue to work on linkages between the baseline program, the various relational databases, and the state's overall designated use assessment process.

Wadeable Streams

For the past four years DNR fisheries and water quality biologists have been applying standardized protocols to address local and basin-wide data needs. Staff have become more familiar and efficient with field protocols and the data entry system. With increasing confidence in the fact that the data being collected can serve both local and statewide data needs, the number of sites assessed and the power of the database has increased markedly.

Since the beginning of the Baseline stream monitoring effort, over 1000 stream sites have been assessed using standardized field protocols to collect stream habitat and fish community data, and macroinvertebrate samples. All data have been entered into an electronic database, and are accessible to staff statewide.

Since all stream assessment sites are geo-located, the distribution of the sampling effort to date has been analyzed to identify geographic data gaps. During workplanning, geographic gaps are recognized and baseline sampling efforts are directed to areas of the state where baseline stream data is lacking. Similarly, development of a GIS data layer that identifies streams by stream order (size) is helping WDNR to disperse the stream sampling effort into differing size-strata of streams (small first and second-order headwater streams) that have been underrepresented in previous sampling efforts. Analysis of populations of streams by ecoregion and stream size helps WDNR define expectations for physical, chemical, and biological conditions to refine management objectives.

Continuing improvements in the baseline program include refining field protocols, field data forms, electronic data entry screens, and automated database output. Using new, lower cost technologies (ie., continuous water temperature recording devices) allow staff to better understand the physical characteristics of streams, critical to developing realistic management expectations. For example without comprehensive water temperature data, fisheries biologists and managers may not be certain if coldwater, cool, or warmwater species should be present or managed for.

In 2002 a USEPA-EMAP project was initiated in the Driftless Region ecoregion. The objectives of this two-year research project are to study ways to improve how WDNR selects and monitors wade-

able streams. The three components of the study are: 1) Develop and institutionalize a probability-based stream site-selection method; 2) Develop a multi-metric index that uses stream invertebrates as biological measures of stream integrity; 3) Use watershed land use, water chemistry, macroinvertebrate, and fish community data - collected at the randomly selected stream sites - to determine the effects of land cover and land use on the quality of stream resources. This data will help improve our understanding and management of factors affecting stream health.

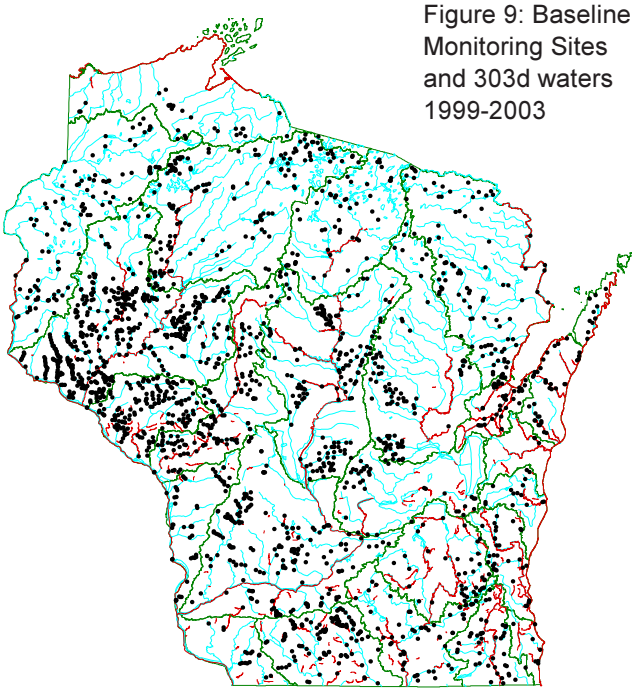


Figure 9: Baseline Monitoring Sites and 303d waters 1999-2003

During the 2003 field season, 60 randomly-selected stream sites located in the Driftless Region ecoregion were sampled. These same streams were also sampled at the nearest "easy-access" point, typically a roadway bridge. A comparison of these paired sites will allow determination of what sort of bias is induced when not sampling truly random sites. When using sample populations to make inferences about target populations (i.e., all streams in the Driftless Region ecoregion), reducing site-selection bias is extremely important, hence the desire to use truly random sites. Conversely, sampling truly random sites can be significantly more time and labor intensive if the sites are far from roadways. Also, landowner access-denial to off road sites, or the need to use more portable sampling equipment to reach random sites can influence which streams or how effectively they are sampled. Findings from this component of the study will have national significance, since many states are or will be incorporating random-sampling designs into their monitoring strategies.

Stream habitat and fish community data, and macroinvertebrate and water chemistry samples were collected at all sites. Two different macroinvertebrate field sampling protocols were used at all study sites. WDNR's standard single-riffle kick sampling, and a 100 meter reach length 20-jab proportional-habitat sample where the 20 jabs are allocated in proportion to the habitat types found. For example if half of the benthic habitat is riffles and the other half is sand-bottomed runs, 10 jab samples are collected in the riffles and 10 jabs are collected along the sandy runs. Findings from this component of the study will help determine whether one protocol is more discriminating than the other at detecting environmental degradation. These findings as well will also be of national significance.

Nonwadeable Streams

A nonwadeable stream is differentiated from a wadeable stream by needing a boat to conduct biological sampling under normal flow conditions -- a stream with a depth of at least 3 to 4 feet for at least 10 miles. Wisconsin has 34 nonwadeable streams with a total length of approximately 2,500 miles. Nonwadeable streams are located in throughout 17 of the state's 23 management basins.

Program Definition and Goals

Wisconsin's Baseline Monitoring – Nonwadeable Streams Program targets rivers that typically have basin areas greater than 650 km^2 (about 250 mi^2), a mean water depth greater than 1 meter and a mean width of greater than 40 meters. Program objectives include determining the biological

potential and evaluating the status relevant to this potential. If a river's potential is not being attained, analysis of monitoring data will help determine which management efforts to pursue. The long-term potential of this program includes identifying changes in ecological integrity or characteristics of sportfish, threatened species, and endangered species. With adequate trend analysis, monitoring data can be used to document changes related to management decisions versus altered disturbance regimes. Monitoring efforts also foster development of biocriteria, habitat indices, macroinvertebrate-based index of biotic integrity (IBI), and baseline data for rivers.

Sites and Sampling Frequency

Monitoring is employed over a broad scale to characterize the variety of Wisconsin's river types and the kinds and intensities of human disturbances upon each river type. We identified 92 reaches on 32 rivers as priority sites. The effort necessitates a strong temporal component to evaluate trends in river health, fish biostatistics, and management over time. Priority sites are to be sampled annually from 2003 through 2007 so we can analyze variation in fishery statistics and then reevaluate sampling frequency.

Parameters Sampled

The standardized fish-shocking protocol for calculating the fish-based IBI on large rivers is the staple of our monitoring. Additional surveys to collect sportfish, threatened species, and endangered species can be done if standard sampling is biased against collecting these species in rivers of interest. A qualitative habitat assessment is performed and basic water chemistry values (e.g., DO, pH, conductivity, and turbidity) are determined once at the time of fish sampling. Macroinvertebrate monitoring will be incorporated in the program after IBI development and testing is complete.

Progress and Plans

In 2003, WDNR sampled 86 sites on 26 rivers. We anticipate a similar level of monitoring through 2007. We are standardizing sampling methods for macroinvertebrates and intend to develop and validate a macroinvertebrate IBI for rivers. Macroinvertebrates were collected from 40 sites on 33 rivers in 2003. Over the next two years, we will sample 40 sites per year, for a total of 140 sites on 36 rivers.

Obstacles

Insufficient funding for permanent staff is the greatest impediment. Vacancies prevented us from sampling 17 sites on 6 rivers in 2003. The protocol should be bolstered for water chemistry analyses, habitat monitoring, and macroinvertebrate sampling but these will be at the expense of fish assessments if funding remains static or is decreased as expected.

Tomahawk, Lincoln County. September 30, 1975. Altitude c. 5,000 feet. Many small kettle lakes, typical of Wisconsin's Northern Highland region, are apparent in this view to the northeast. Perhaps ninety percent of this landscape northeast of Tomahawk is forested and in full fall color. Dark green conifers contrast with brightly-colored maples and other hardwoods. Picture courtesy of the The Carl Guell Slide Collection at the Department of Geography, University of Wisconsin Oshkosh

Lakes

The goal of the baseline monitoring strategy for lakes is to determine the status of and trends in the health and condition of high visibility lakes and their fisheries, as measured by fish populations, fish community characteristics and lake trophic status. The focus of the strategy for lakes is to evaluate the effects of broadscale human use, such as changes in land use, shoreline development and angling or lakes. All high visibility waters, and a sub-sample of other waters, are sampled. The information collected provides:

- An inventory of lake health and condition
- A context for comparing data collected among lakes and the capability to compare similar lakes to each other.
- Standardized methods and data to evaluate statewide management activities.
- A screening tool to initiate more in-depth field investigations to confirm apparent water quality or fisheries problems.
- Effective surveillance for nonindigenous/invasive species occurrence.
- A comparison of lake health and condition through time.
- Synoptic data on the impacts of stressors on fish communities and trophic status.
- A comprehensive data set on the state's lakes that can be used for project planning and individual lake assessments.

    - The capacity for statewide determinations about overall lake resource health and condition.
    - Spatial data within a stratified design to develop an index of statewide lake condition.
    - Inferences on the condition of non-sampled lakes.
    - Information on the attainment status of lakes for aquatic life use designations.
    - Integration of existing Water Division monitoring programs.

Below are four objectives considered critical to the success of a lake monitoring program. In addition, a proposal for trends monitoring is incorporated into the plan for baseline/condition monitoring because both are vital to achieving the goals for lake monitoring.

- Objective 1. Assess the health and condition of lakes and their fisheries.
- Objective 2. Assess trends in the health and condition of lakes and their fisheries.
- Objective 3. Continually improve the baseline monitoring program.
- Objective 4. Determine links between human uses of lake resources and lake ecosystem health.

Lakes Managemement - A Tiered Approach

The Baseline Lakes Monitoring Program collects fisheries and water quality data on a wide variety of lakes each year. To make sense of the information, the data are stratified into 6 different lake types. Lake classification reduces variance within a class and maximizes variance among classes, allowing you to compare "apples" to "apples". Expectations for fisheries and water quality vary depending upon the type of lake. These data provide a "baseline" with which to compare similar lakes to each other.

For example, looking at summer secchi depth data (Figure 10), shallow lowland drainage lakes typically have the poorest water clarity (about 4 feet) whereas deep seepage lakes typically have the best water clarity (about 12 feet). This lake classification scheme accounts for differences in watershed area, maximum depth, and water source. Shallow lowland lakes are unmixed lakes receiving water from large drainage basins; deep seepage lakes are stratified lakes with predominantly groundwater inputs. In general, shallow (less than or equal to 18 feet maximum depth) unstratified lakes tend to have poorer water clarity than their deeper counterparts. Therefore, even the best shallow lowland lake should not be expected to achieve water clarity values that are similar to a deep seepage lake.

The same approach is used for other components of water quality. Figure 11 (next page) shows another exampling using Total Phosphorus, measured in spring prior to lake stratification and in summer at peak stratification, is highest in shallow, unmixed drainage lakes (lowland and headwater).

Figure 10:

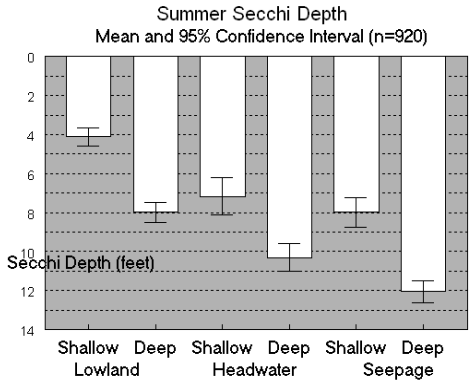
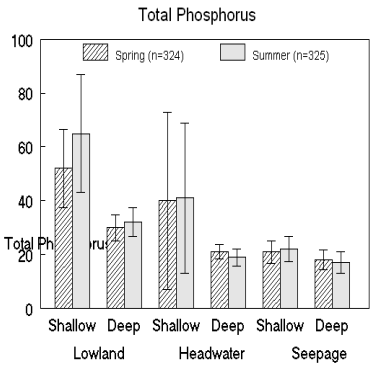


Figure 11:

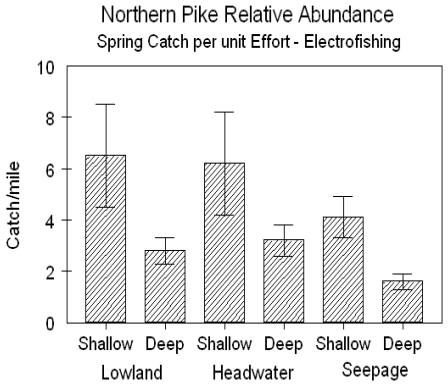


Similarly, this approach is used for biological data collected though the Baseline Lakes Monitoring program. Figure 13 shows that northern pike catch per unit effort (CPE) is typically higher (with higher variability) in shallow lakes than in deeper, stratified lakes. Northern pike CPE is lowest in deep seepage lakes. These averages are produced for each species, which then form the basis for management goals within each type of lake.

Status Lakes

The Lakes Baseline Strategy also calls for additional types of monitoring on selected waterbodies. For example, staff will sample "Status Lakes" one time in the spring for total phosphorus and one time in the summer for TSI components (total phosphorus, sechhi disk, and *chlorophyll a*). This work is coordinated with the lakes volunteer monitoring program to avoid duplication.

Figure 12:



Trend Lakes

The program also samples 56 lakes statewide for long-term trends, which provides a much needed long-term temporal and spatial dataset which can be used for reference conditions for defined lake classes. This data is also used to characterize within lake and among-year variability in baseline water quality monitoring.

Wetlands

The Department's "Wetland Team" is developing a wetland assessment and monitoring program following an approach endorsed by a federal USEPA Workgroup on wetlands. This approach has three levels and is designed to maximize efficient use of scarce resources for wetland monitoring while gathering scientifically valid information to address management needs. Level 1 is Landscape Assessment relying on coarse, landscape-scale inventory information, typically gathered through remote sensing and preferably stored in, or convertible to, a geographic information system (GIS) format. Level 2 is Rapid Assessment at the specific wetland site scale, using relatively simple rapid protocols. Level 2 assessment protocols are to be validated by and calibrated to Level 3 assessments. Level 3 is Intensive Site Assessment using intensive ecological evaluation methodologies, particularly research-derived multi-metric indices of biological integrity. The Department's strategy is to develop complementary wetland condition assessment tools that can be used across the broad spectrum of wetland types at both the site-specific and landscape scales. Publications describing the methods developed by DNR are available on the DNR's Wetland Assessment and Monitoring web page: http://dnr.wi.gov/org/water/fhp/wetlands/assessment.

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Pathogens

The 2003 beach season earmarked the implementation of the first comprehensive beach-monitoring program in the State of Wisconsin. The Water Quality Standards Section secured grant funding from U.S. EPA for development of a comprehensive beach-monitoring program. The primary focus of this program is the Great Lakes coastal waters Lake Michigan and Lake Superior although some inland lake monitoring will occur during the 2004 beach season. One of the program goals is to monitor selected beaches along the Great Lakes in accordance

with the federal Beaches Environmental Assessment & Coastal Health (BEACH) Act requirements. The program requires prompt notification to the public whenever bacterial levels exceed EPA's established criteria and establishes a beach monitoring and public notification plan. This plan is designed to assist lakeshore communities improve monitoring of and notification procedures for high bacteria levels.

Fixed Station/Long Term Trend Monitoring

In Wisconsin the U.S. Geological Survey operates 110 long-term flow gages, most of which are at least 60% supported by cooperators (Figure 13, next page). There are over 30 cooperators including the COE, FERC regulated dam owners, native American tribes, planning agencies, counties, cities, sewerage districts, as well as the WDNR. Real time data from all sites are available from USGS.

WDNR currently directly funds 14 of these flow gages at a cost of $77,000. USGS provides the match. Hydrolelectric dam owners fund about 20 additional sites. USGS has been successful in getting other local cooperatiors to pick up past reduction in funding from the WDNR so the total number of sites has stayed fairly constant.

A major review of the statewide flow-gaging network was published in a 1998 UW-Water Resources Institute Report. Annual meetings with USGS and their cooperators are held to review the current status of the statewide effort and to discuss changes in funding ability or priorities of the different groups. WDNR prioritizes funding sites that are uniquely critical to our needs as well as to fill in gaps to assure appropriate statewide coverage. WDNR's current goal is to at least maintain the current level of funding with increases to cover inflation while watching the needs that may arise due to new environmental concerns or reductions in fuding by other USGS cooperators.

In 2004, WDNR expanded its number of short-term TMDL-related gages to five sites. Installation of a gage is a significant cost that USGS does not cost share. USGS has offered to cost share the operation of these sites at a 25% level. This is reduced from the 40% match for the long-term sites due to limitations in the amount of match money available and because these sites are generally of less use to other data users. WDNR's desire is to fund needed TMDL-related sites without reducing support of the long-term sites. In a review of the long-term sites co-funded by DNR, 10 sites were identified to support groundwater and high capacity well issues, long-term water quality needs, development of TMDLs, and floodplain zoning work. Many more sites would be useful and requested if money for long-term support was available.

Sediment Monitoring

Sediment monitoring is conducted as part of baseline condition monitoring or for special projects to 1) investigate areas with contaminants associated with pollutant sources, 2) investigate areas of fish advisories, 3) establish reference/background concentrations of metals and organic compounds through various sampling efforts, 4) determine pre-dam removal assessments or other stream disturbance assessments, and 5) assess contaminated sediment sites. Sediment mapping is conducted as part of the sediment investigation, monitoring and evaluation program.

Special Studies Monitoring

Special study monitoring projects include data gathering beyond the routine baseline monitoring program work. Because the baseline monitoring program does not routinely include water chemistry work, program monitoring requiring chemistry data is considered "special project" monitoring. These types of studies include validation monitoring for 303d listings, TMDL study monitoring, background monitoring for effluent limit calculations, dissolved oxygen studies or fish kill investigations. Several special project monitoring studies occurred during the 2003-04 reporting period, many of which involved TMDL work.

Fish Tissue Monitoring

During calendar years 2002-2003, over 1800 fish samples were collected as a part of the fish

Figure 13: 2003 USGS Gage Stations

contaminant monitoring program (Table 5, as of April 2004). This includes fish samples that were collected as a part of the normal fish contaminant monitoring program, samples collected by cooperators, and samples collected under special projects and research.

In 2002-2003, samples were collected from approximately 137 lake locations, 36 sites in flowing waters, and 19 areas of Lakes Michigan and Superior (preliminary data as of April 2004).

Each year WDNR collects and analyzes samples of fish tissue from Wisconsin's inland waters and the Great Lakes, including their tributary streams. The objectives of the fish contaminant program includes protection of fish consumers by determining the levels of bioaccumulatory contaminants in the edible portions of fish and compare these levels to health guidelines as determined by the Wisconsin Division of Health.

Samples from the Great Lakes were analyzed for PCBs, pesticides, and mercury, while samples from river systems were primarily analyzed for PCBs and mercury. Fish samples from inland lakes were analyzed almost exclusively for mercury.

Fish consumption advisories are issued for certain species and sizes of fish from given areas where the concentrations of chemicals in the fish flesh exceed the health advisory levels. Fish contaminant data is also used to make natural resource and environmental management decisions.

Table 5. Wisconsin's Fish Contaminant Monitoring Summary 2002-03

Time Period	Sites Sampled **	Samples Collected **
Prior to 1980	233	3,003
1980-1989	978	11,139
1990-1999	770	11,565
2000-2001	209	1,824
2002	110 *	997 *
2003	96 *	881 *
Total Cumulative	**1,634 ***	**29,409***

* Total number not yet available, based on data available as of April 2004. (Total cumulative number of sites does not include duplicate visits to a site.)
** includes samples collected and/or analyzed by cooperators

Through the WDNR baseline strategy for lakes and streams, fish are collected for contaminant analysis at a subset of sites where data is needed. This monitoring is conducted to determine statewide distribution of contaminants, provide a comparison of the levels of contaminants between impacted sites throughout the state and with unimpacted (reference) sites, and to determine if intensive monitoring is needed at a given site.

In addition to baseline monitoring, special assessments monitoring is conducted to update advisory waters and to document change resulting from remediation. In addition, WDNR uses fish tissue monitoring for source investigation, to track the effectiveness of remediation efforts, and to determine potential effects of toxic substances and contaminated sediments on fish-eating birds and wildlife.

Another major element of fish tissue monitoring is the assessment of contaminant levels for Lakes Superior and Michigan and their tributaries. This trend assessment, requiring the collection of game and forage species biennially, helps determine contaminant trends and possible geographic patterns.

Volunteer Monitoring

Lakes Volunteer Program

Wisconsin has had a solid volunteer monitoring program in place for lakes for several years. Self-Help Citizen Lake Monitoring and the Self-Help Volunteer Lake Monitors have been an integral part of the Wisconsin lake management since 1986. Citizens who live on their lake and know their lake better than anyone else have volunteered themselves in partnership with the Department of Natural Resources. This concept has been so successful that Self-Help Citizen Lake Monitoring was expanded to include volunteer opportunities for chemistry, dissolved oxygen monitoring, and aquatic

plant surveys. Since its beginning, over 3200 volunteers have participated in the program on over 1000 different lakes.

For the lakes program, WDNR provides all equipment. Training is provided by either WDNR or University of Wisconsin-Extension staff (UWEX). Volunteers provide their time, expertise, energy and a willingness to share information with their lake association or other lake residents. The information gathered by the volunteers is used by lake biologists, fisheries staff, water regulation and zoning, UWEX office, lake associations and other interested individuals. For example, data from this program is used extensively in the state's 305(b) assessment database, now called the Waterbody Assessment Display and Reporting System (WADRS), which is summarized in this report.

Rivers Volunteer Program

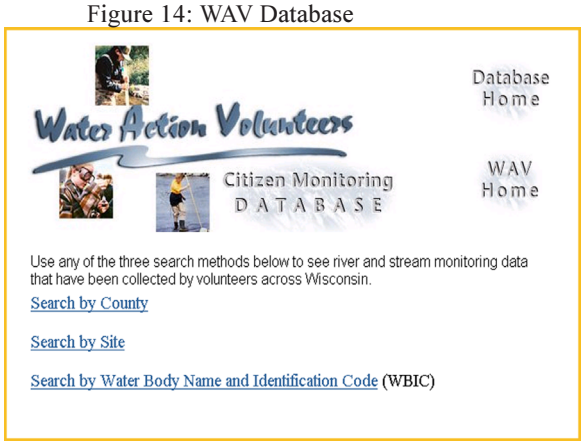
Citizen stream monitoring in Wisconsin is coordinated as an educational and baseline monitoring effort through the Water Action Volunteers Program (WAV), an outreach education program for Wisconsin citizens that involves stream monitoring, storm drain stenciling, and river and shoreline cleanup programs. The program is coordinated through a partnership between the WDNR and UWEX. It is carried out via partnerships with locally-based professionals and volunteers from a variety of counties, non-profit organizations, nature centers, interest groups, and schools.

When developed in 1996, a premise of the stream monitoring portion of WAV was to standardize monitoring techniques across the state so citizen monitors would be able to share information across streams and sites because they were using the same methods and monitoring technologies. The goals of the program are to offer Wisconsin citizens an opportunity to monitor stream and river health, to support data sharing for educational purposes, to provide a network for volunteer monitors to interact, to provide support of civic conservation groups wishing to engage in stream monitoring, and to increase linkages between volunteer monitoring efforts and public resource protection programs.

To learn more go to:
http://clean-water.uwex.edu/wav

By the end of 2003 there were 25 local programs with 200 adults and 600 students monitoring 135 streams at nearly 250 sites across the state. Today, most adult volunteers monitor stream flow, dissolved oxygen, temperature, and turbidity monthly from April until October; habitat is monitored once per year, and macroinvertebrates are assessed twice a year. Students usually monitor in spring and fall as a classroom activity, though some active school groups and ecology clubs monitor throughout the year. In 2003, 25 trainings were held for 400 individuals.

Figure 14: WAV Database



Since 2002, citizen volunteer monitoring data for streams has been entered into an internet accessible database. Over 2000 days of data have been entered by trained data coordinators from each of the local programs. The database, hosted by UWEX, is designed with a number of quality assurance checks and automatic calculations to help ensure good quality data. At the website, anyone with internet access can search the data by county, site, or stream name. Data are summarized and prepared into brochures for use by local citizens' groups, which are also accessible through the WAV database. An online mapping system that will link the WAV citizen stream monitoring database and the Self-Help citizen lake monitoring database is in the works with a partnership between the two monitoring efforts and the state's Aquatic and Terrestrial Resources Inventory (ATRI).

In the fall of 2003, WAV, in partnership with volunteer stream monitoring programs in five other states, was awarded a three year grant from the USDA Cooperative State Research Education and Extension Service (CSREES) to study and implement *E. coli* bacteria monitoring with volunteers in streams of the upper Midwest. Initial project planning began in late fall of 2003 to study the usability and reliability of five different *E. coli* test kits with volunteers. Studies will include comparison of test kit results to certified laboratory results of *E. coli* concentrations as well as comparison of test kits

based on volunteer and staff preferences. Efforts are being made to link this project's efforts to existing beach monitoring programs in each of the participating states. For project information visit:

In 2003 a grant was awarded to the WAV program and partners at the University of Wisconsin and WDNR through the Ira and Ineva Baldwin Fellowship to conduct *"Water for Everyone,"* which is designed to address the need for additional education for citizen monitors and trainers to enhance the quality and usefulness of the data.

Use of Volunteer Data for Water Quality Management

Volunteer river data is a valuable contribution to the suite of information used in resource decision making. For years, lakes program volunteer data has been used for 305(b) assessments. With the development of Basin Partnership Teams and the Rivers Grant Program, as well as the evolution of the WAV program, volunteer river data is becoming more reliable and readily availble to resource managers. Currently, volunteer data indicating water quality problems can provide a "red flag" to DNR biologists to conduct further investigation. However, due to the complexities of river systems, differences between the goals of the WAV program (primarily educational) and the level of structure and quality assurance needed for trend assessments and regulatory decisions, in the past citizen data have not been widely used for designated use assessments.

Future enhancements of the WAV program will increase the usefulness of the data for state agency decision making. These changes include more quality assurance controls, monitoring design and laboratory support, and biologist outreach.

Currently, the program provides some very interesting results and biological and habitat assessments have been used locally and incorporated in selected basins' State of the Basin report.

Water Quality Modeling

WDNR uses water quality modeling to manage water resources. Modeling helps assess the assimilative capacity of a stream (how much of a pollutant a stream can carry and dilute without harming aquatic life) or the movement of pollutants in an aquatic ecosystem. Models are also used to help determine causes of existing water quality problems, to evaluate responses to proposed management options and to predict future changes likely to occur without any management action.

Lower Wisconsin Basin

In Otter, Brush, and Black Earth Creeks, and Pine River watersheds of the Lower Wisconsin Basin, ten sites were monitored between 2000 and 2003.

- Black Earth Creek behind fire station in Cross Plains
- Black Earth Creek downstream from County KP in Cross Plains
- Black Earth Creek at Salmo Pond Park
- Brush Creek UW-Richland pedestrian bridge
- Brush Creek 17th drive at Kampf's
- Flint Creek below Harker/Lee confluence
- Harker Creek up from Lee Creek
- Lee Creek up from Harker Creek
- Pine River at old Richland Center dam site
- Pine River at junction County Hwy C & Dove Lane

Turbidity was measured monthly at most sites, sporadically at others. Of 118 observations, more than 80% found good water clarity with no negative effects on aquatic life. Storm events resulted in concurrent elevations in turbidity, with peak levels reached prior to the end of the storm. The fact that it was raining when the highest turbidity was recorded suggests that streamflow and erosion were affecting turbidity.

Development of water quality models often requires the collection of extensive amounts of data on existing water quality and stream flow, as well as the many factors that can affect water quality. Data requirements vary depending on the type of model and its intended use. WDNR uses models in the following areas:

- Stream dissolved oxygen models for waste load allocations
- Contaminated sediment transport models
- Watershed loading models
- Lake response models
- Mixing zone models

Beginning in the mid-1970s, WDNR developed waste load allocation models on stream segments such as the Wisconsin and Fox Rivers where multiple point sources contributed to water quality problems. The allocations were used to establish water quality based effluent limits for industrial and municipal point source discharges. The WDNR is currently re-evaluating allocations for Segment A of the Wisconsin River from Rhinelander to Tomahawk.

Contaminated sediment transport models are used to predict the transport and fate of sediments containing chemicals of concern. Fate and transport models help to predict the bioavailability of contaminants to the food chain but not the concentration of chemicals in the food chain. For this, food chain models are used. In particular, WDNR models sediments containing high levels of polychlorinated biphenyls (PCBs) to determine the rate of PCB movement and the biological concentration of the chemical in the food chain, and to predict the potential benefits from selected cleanup options. WDNR has applied fate and transport models to the Lower Fox, Sheboygan and Milwaukee River systems and all are on file with the Great Lakes National Program Office. While the Sheboygan and Milwaukee studies were screening level models and the Fox a much more detailed model, all three studies were developed for comparison with predictions made by USGS based on the Great Lakes steam tributary monitoring project.

Watershed loading models link pollutant export from various land use practices to loads in streams and lakes. WDNR uses both screening level (export coefficient) models, as well as more detailed mechanistic process based models such as the Soil and Water Assessment Tool (SWAT), a Barnyard Evaluation Model currently under development , the Source Loading and Management Model (SLAMM) and the P8 Urban Catchment Model. WDNR is also working with the U.S. Department of Agriculture, Agricultural Research Service, the developers of SWAT, to test and refine SWAT for application to agricultural practices in Wisconsin. SWAT is one of a number of modeling and analysis tools identified for TMDL development in Wisconsin.

Lake models predict the changes in lake trophic state, as reflected in total phosphorus concentration, water clarity and the severity of algae blooms, to changes in nutrient loading to a lake. The purpose is to determine how individual lakes will respond to changes in land management practices or proposed lake restoration activities. The Wisconsin Lake Modeling Suite (WiLMS) is a lake and watershed evaluation tool developed by WDNR and currently used throughout the state for lake management. It is used for about 80% of the six to eight lakes modeled per year in Wisconsin. WILMS also is used extensively by consultants working on lake planning and protection grant projects. The Army Corps of Engineers BATHTUB model is used for the other 20%.

WDNR reviews mixing zone models that are part of applications for modified mixing zones for industrial and municipal dischargers. Results are used to determine effluent limits for toxic compounds to protect fish and aquatic life in the receiving waters. Mixing zone models are a tool for determining the extent to which a diffuser outfall enhances rapid mixing of the effluent and reduces toxicity to aquatic organisms that may be caused by specific pollutants.

Laboratory Analytical Support

The DNR has annual contracts with the Wisconsin State Laboratory of Hygiene (SLOH) for water chemistry and sediment chemistry analyses. Physical analyses for sediment studies are conducted at UW-Madison Soils Laboratory. DNR contracts with UW-Stevens Point and UW-Superior for macroinvertebrate analyses and with various external, state-certified laboratories for parameters not covered by the existing state contracts.

Data Storage, Management and Sharing

Wisconsin has a growing number of systems to store, manage and share its aquatic monitoring, assessment, and implementation actions data. WDNR utilizes Geographic Information Systems (GIS) as a tool for water quality management, employing a systems approach to integrate data and assist in analysis. The latest technology uses GIS to link information from diverse sources in a "map view", allowing managers to use both spatial and tabular data to identify and analyze resource issues and problems. Not all DNR data systems are currently accessible via GIS; however, long-term plans for the Department involve converting key data systems to a GIS-compatible format. The foundation for the Water Division's data integration efforts has historically been the Surface Water Integration System (SWIS), described later in this section.

In fall 2003, the water program began reviewing and evaluating the its information technology or data systems. The objectives of this analysis were:

- document the status of data systems,
- define business priorities and determine where data systems are supporting or failing to support priorities, and
- provide recommendations to guide new system development and insure effective use of data systems in the future.

Through the use of the internet, many activities that previously occurred through expensive desktop applications can now take place through the use of the internet or through shared server applications. This "revolution" of sorts is changing the way the water program is configuring its data systems.

Today, the major focus of work is the integration of a spatial component or "map view" into existing tabular relational database systems so that the data of interest can be interactively viewed and edited. Once the point is located through the use of this "embeddable locator tool", managers can access the data in map view through the WDNR Water Program "Watershed MapViewer", where multiple datasets can be overlaid in an ArcIMS mapping application. This 'data integration' can occur through a simple web-based mapping application where datalayers are provided one on top of another. The data can also be viewed and analyzed through the state's advanced GIS tools in the Surface Water Integration System (SWIS).

Users of SWIS can specify conditions on the types of data requested so that relevant data is pinpointed to maximize decision making efficiency. For example: once the STORET system is incorporated into SWIS, for a given watershed (stream, basin or statewide), the user will be able to report back:

- all water chemistry data for a particular parameter (ie., total phosphorus) at a given level (ie., greater than 10 ppm, for example);
- all outfalls that discharge phosphorus equal to or greater than a certain level (1 mg/l);
- locations of usgs gage stations and related flow data;
- segments and/or waterbodies listed for excess phosphorus or turbidity on the 303d list;
- codified use, impairments sources and pollutants of those waterbodies;
- locations of best management practices to control phosphorus and/or sediment.

From the query, the user receives both a spatial display of the waterbodies of interest as well as a linked table showing integrated data of interest. This is just an example, but illustrates that analyzing cumulative impacts for regulatory or non-regulatory decision making will be much improved as the Department is able to get more data into the SWIS system.

Surface Water Integration System (SWIS)

To maximize the benefits of a GIS for water management, WDNR initiated development of a Surface Water Integration System (SWIS) in 1992. The SWIS is designed to integrate diverse data associated with water features. These datalayers can then be analyzed using built-in tools within SWIS. The 'base' datalayer, or framework, through which multiple surface water related databases are integrated is the 1:24,000 scale hydrography layer (see below). An updated hydrolayer (version

3.0) is available for data integration work. Continuing refinements to the configuration of this base datalayer will further advance its usefulness in the department.

1:24,000 Scale Hydrography Layer

In October of 2000, DNR produced the state's first 1:24K Hydrography geographic data layer from 1:24,000-scale sources. This DNR corporate datalayer is integral to integrating various DNR databases related to waterbodies. Since the initial release of the WDNR 24K Hydrography database, a series of updates and enhancements have been completed, resulting in Version 3. A history shapefile has been created to track all features that have been spatially edited. Version 3 is now available for distribution on CD including the full 24K Hydrography data model in ArcInfo coverage format and as the 24K Hydrography data in shapefile format, accompanied by several preconstructed ArcView legend files intended to facilitate use of the data. The coverage and shapefile versions are both provided statewide in extent and accompanied by the full set of current user documentation.

During the coming reporting period, DNR will undertake a complete review of hydrolayer data model, evaluating how to enhance the coverage to provide four critical features that are currently not available: 1) statewide connectivity (to support modeling work), 2) coverage beyond the 1:24K scale to support program needs involving waters that are not represented on the 1:24K scale, 3) timely edits to reflect documented changes in waterbody movement, size or configuration (ie., dam removals), and 4) consistency between the register of waterbodies (ROW, the state's waterbody inventory) and the 1:24,000 scale hydrography spatial datalayer for name, location, waterbody identification codes (WBICs), and length/size.

Spatially-Enabled Data

Wisconsin's SWIS links geographically located ('geolocated') data points, lines or polygons together in one system for integrated data analyses or queries based on water features represented in the 1:24:000 Hydrography datalayer. Currently, the following systems are "geolocated" in SWIS: Register of Waterbodies (ROW); Master Fish File, Engineering Studies, NHI data for riverine species, dams, fish toxics, sediment toxics and General Permit Facilities (Milwaukee County only). In FY05, the following additional datasets will be "geolocated":

- Waterbody Assessment Display and Reporting System (WADRS) [waterbody classifications, use designations, assessments] July 2004 (QAQC in 2005);
- STORET (geolocation in Fall, 2004 (QAQC in 2005);
- Outfalls (point geolocation in June 2004, attribute data in 2005);
- Biological and Habitat Database (possible geolocation in 2004-05, attribute data in 2005-06);
- Exotics (zebra mussels and eurasian watermilfoil geolocated in 2004, attribute data for these and additional species in 2005-06).

Embeddable Locator Tool

A new geolocating tool called the Embeddable Locator Tool (eLT) has been developed and is being deployed in several WDNR applications to allow for the collection of more accurate locations. This mapping tool is called from the data system maintenance screens that staff use to enter new site locations and/or change existing ones. The eLT allows users to use create locations against Digital Orthophotos, Topo quads and other vector GIS data while they type in all of their attribute data. The tool also gives the staff the capability to "link" their location to the 24K Hydrography network and thus make their data available to others through SWIS.

Additional Data Management Projects

Fish and Habitat Statewide Database

The Fisheries and Habitat Database is an Oracle system developed by the Bureau of Fisheries Management and Habitat Protection through the United States Geological Survey (USGS), Powell Data Center. The database consists of data entry forms, exporting and reporting capabilities, and tools for analysis of fisheries and habitat data for streams, rivers and lakes. The FH Database directly

supports the state's Baseline Monitoring Program in addition to other Fisheries and Habitat programs by providing an electronic "warehouse" to store fisheries and habitat data via a WEB-based application for data input and access. Since 2002, the FH Database has provided automated outputs of selected metrics for the identified media (lakes and rivers and streams) such as Index of Biotic Integrity (IBI) for fish data, and Habitat Indices, in addition to summaries used to answer local fisheries management questions about fish distribution, abundance, size, growth, recruitment, and mortality.

Currently, the database focuses exclusively on biological data, as chemical data are stored and accessed through STORET. However, work is being conducted to analyze connections between these two databases and with the state's SWIS.

Aquatic and Terrestrial Resources Inventory

The Aquatic and Terrestrial Resources Inventory (ATRI) is "a public and private partnership to gather, link, and make available data used for making decisions affecting Wisconsin's landscape." It is an integrated information management system that currently functions as an inventory of data, regardless of location or format. The goal of the program is the identification, inventory, storage and distribution of Wisconsin's ecological data. Products of the program include a metadata repository, department data standards which provide guidelines concerning the collection and structure of data that is consistent with current WDNR practices and recognized federal standards. The inventory is available to anyone with internet access, and includes interactive mapping using ArcIms.

Sediment and Fish Toxics Database

This oracle system contains sediment sample and fish tissue results used to track ambient sediment contamination levels and to develop the state's fish consumption advisories. This system will bereviewed during FY05 to identify possible enhancements to broaden use and accessibility of the system.

Register of Waterbodies – ROW

The Register of Waterbodies is the state's inventory of waters and is an Oracle-based system originally developed from historical county waterbody listings and descriptions. During the 2002-04 reporting cycle, the state invested resources to upgrade this waterbody identifying assignment system to update its interface to a web-enabled java user interface with a spatial component, or map view embedded in the system. These updated features will be available to DNR staff in 2004.

Master Waterbody Fish File

This database holds the sites of fish specimen collected using USGS Quads and Wisconsin Transverse Mercator (WTM 83/91). The purpose is to inventory the fish species and their distribution in Wisconsin waterbodies. This data was compiled by the Wisconsin DNR for fisheries inventory and monitoring and is stored in an Oracle database.

Wetlands Inventory

The state's Wetlands Inventory is a 1:24,000-scale GIS-based coverage containing all digitized wetlands down to at least 5 acres in size, and in some areas down to 2 acres in size. This database, used for regulatory purposes, is a critical element in the state's water management program. In 2001, a project was completed that makes this data more accessible to resource managers (see below).

Wetlands Datalayer GIS Coverage Clipping Project

The DNR completed a manipulation of the Digital Wisconsin Wetlands Inventory (DWWI) that allows the digital wetlands layer to be accessed and displayed by water basin in Arcview. Each major water basin or Geographic Management Unit (GMU) has an associated "clip-out" of the DWWI that displays the wetlands of the basin. The basin "clip outs" are available on the DNR's GIS library. This has made DWWI information much more accessible for basin planning and 305 (b) reporting. Summaries of wetland acreage by wetland type can now be provided for each water basin, and the

distribution of wetlands throughout the basin can be displayed. Year 2000 -2002 State of the Basin Reports used this data. Prior to this project wetland information could only be displayed by county. The protocol developed for this project is also applied to "clip-out" the DWWI for subwatersheds to meet specific project needs.

Lakes Volunteer Monitoring Database

This database has undergone tremendous growth and change since 2001, when it first became accessible to the public through a web-based application on the DNR's website. This Oracle based application provides up-to-date information to residents on the quality of their lake through a series of pre-designed report formats. This system is described more fully in the Lakes Assessment Data Chapter 3.

Waterbody Assessment Display and Reporting System (WADRS)

The state's water quality assessment system is described in Chapter 2.

Chequemenon Bay, Lake Superior Photo: Courtesy of USEPA